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Diversity and Seasonal Fluctuation of Coleoptera Community in the Reserve Forests of Aravalli Range at Jaipur, Rajasthan, India

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ABSTRACT

Coleopterans are a diverse insect taxon that includes beetles and weevils. They are an important part of the food chain in the ecosystem, chiefly participating in energy radiation, mineral recycling, and pollination in the terrestrial ecosystem. The diversity of coleopteran fauna in the forest ecosystem of the north-eastern Aravalli range was studied from March 2021 to February 2022 in two reserve forests: Jhalana forest and Galta forest, Jaipur, by employing random sampling in 10 x 10 m quadrates with the aerial sweeping method. The field survey comprised 2046 specimens of Coleoptera, representing 56 species in 12 families of the two suborders, Adephaga and Polyphaga. The Scarabaeidae family was the most dominant with 15 species, followed by Meloidae with 7 species, whereas Bostrichidae, Dermestidae, and Ripiphoridae represented only one species each. The highest abundance was recorded during the monsoon season. Across the study, Shannon's Diversity Index (H'), Simpson's Diversity Index (D'), Dominance, and Evenness were calculated as 3.065, 0.9418, 0.05819, and 0.7389, respectively, which reflects that the coleopteran fauna is quite diverse in the surveyed forest habitats. The comparatively higher value of the diversity indices revealed in Jhalana forest might be due to the occurrence of nascent habitat for coleopteran fauna with fewer disturbances. Understanding species diversity and distribution patterns is important to evaluate the ecosystem's complexity and resources in these protected areas. This study will be the first documentation of the insect fauna of this reserve forest, and more field investigations are recommended.

Keywords Coleoptera, Species richness, Aravalli range, Jhalana Forest.

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INTRODUCTION

Coleoptera is a diverse insect group dominating agricultural land, grassland, and forests, representing about 3,89,487 described species globally (Zhang 2013), of which about 22,334 have been reported from India (Chandra *et al.* 2018). Coleoptera are primitive insects that are classified into two suborders, Adephaga and Polyphaga. It comprises beetles and weevils and is widely distributed worldwide except in permanently ice-covered areas. The abundance and diversity of coleopterans vary according to vegetation, temperature, relative humidity, and elevation. Many coleopteran species excellent bio-indicator species and can be used in grassland ecosystem monitoring. These insects significantly trap the energy from autotrophs and help to radiate it up to higher trophic levels. They are considered potential agricultural pests and are also considered a vital component of ecosystem services as food for mammals, amphibians, and birds. Hence, they are an important group for making the ecological food chain more sustainable in terrestrial habitats.

The Aravalli hill range is the country's oldest hill range, with a folded stub nature, located at 2500N 7330E, beginning in Gujarat, passing through Rajasthan and Haryana, and ending in New Delhi. Coleopteran diversity in Rajasthan has been documented in various isolated patches by Roonwal (1983), Ghosh *et al.* (1996), Vazirani (1970), Kazmi and Ramamurthy (2004), Sewak (2009), Sharma (2016), and Tak and Srivastava (2015), Prajapat *et al.* (2022) who have made significant contributions to understanding the beetle diversity in the Aravalli range. Previous studies focused on agroecosystems as a means of documenting agricultural insect pests, and lacked data from the forest habitats of the Aravalli range in the state. In the present study, the coleopteran diversity was investigated in two protected areas: Jhalana Forest and Galta Forest of the Aravalli range in Jaipur. The biodiversity of coleopterans were determined at both study sites, which have different altitudinal gradients and microhabitats. This study also aimed to make a modest attempt at examining the effect of anthropogenic influences on coleopteran fauna through a comparison of the coleopteran diversity in two reserve forests of the Aravalli range with its diversity statistics.

MATERIALS AND METHODS

Study Area

The Aravalli is one of the oldest hill ranges, with eroded and folded nature hills, and covers a distance of about 550 km in the state. It is characterized by a sub-tropical type of climate with dry deciduous forests that include *Tectona grandis, Anogeissus pendula, Acacia nilotica, Butea monosperma* and others. The daytime temperature varies from 40 to 46°C during the summer to 1.5 to 4°C during the winter. The southwestern part receives maximum rainfall during the monsoon, which is about 150mm annually. For the survey and sampling of coleopteran insects, two sampling sites of Jhalana Forest Range, Jaipur were selected viz., Jhalana Forest and Galta Forest, which are reserved under the "State Forest Act, 1953" for the conservation of wild flora and fauna in the Aravalli landscape (Table 1, Fig. 1).

Jhalana forest: It is a pioneer reserve for leopard conservation, declared in 2017. The total area is 20 square kilometers and is situated in the foothills of the Aravalli Range. The reserve is dominated by deciduous *Acacia-Anogeissus pendula* forest, with grass patches scattered among the foothills.

Galta forest : It is about 10 kilometers from the city. The forest is dominated by sparse scrubland and deciduous Acacia forests, invaded by *Prosopi juliflorea* and *Lantana camara.* It has famous for ancient Hindu pilgrims named Galta Ghati and Kund. Hence, many types of anthropogenic activities along with sacred activities have been observed during the survey, viz., cattle grazing, firewood collection, and plant invasion.

Survey, collection and identification

The weekly field survey and collection were carried

Table 1. General characteristics of the study sites.

Sl. No.	Sites name	GPS location	Sampling habitat types	Elevation
1	Jhalana Forest	26°55'2.61"N, 75°51'28.82"E	Grass patches between foothills	280-530 M
2	Galta Forest	26°51'18' N, 75°49'58.08' E	Rocky out cracks, scrublands with anthropogenic activities	230-460 M

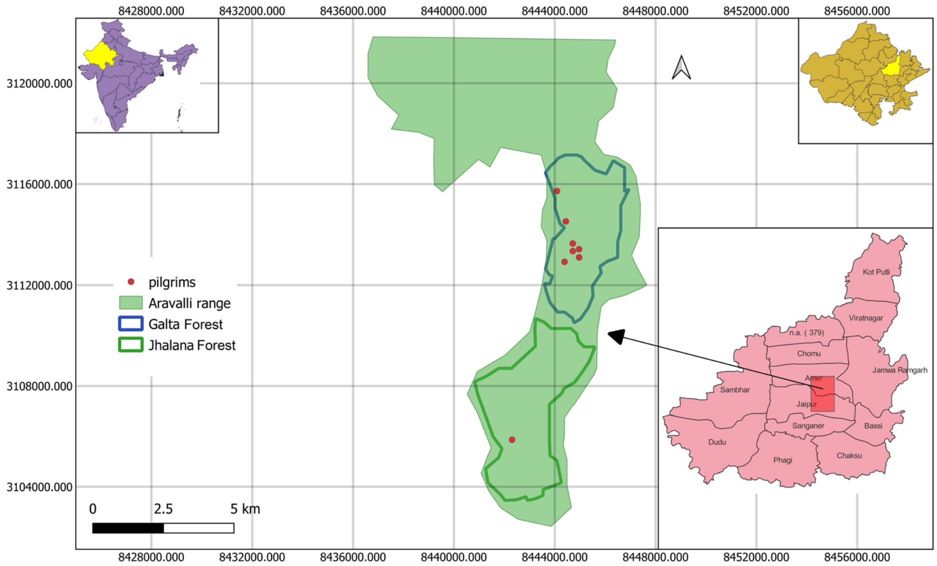

Fig. 1. Map of the study area with study sites.

out by the general hand sweeping method with the help of an aerial sweep net from 6:00 am to 12:00 pm, from March 2020 to February 2022. An annual survey period was categorized into three main seasons: Pre-monsoon (March- June), monsoon (July-October) and post-monsoon (November-February) to determine the seasonality pattern of insects in the study area during two consecutive years. The random, 10 × 10 m-sized quadrates were selected for the field survey. At both study sites, the linear transect (150-200 M) method was used for the insect sampling. The collected specimens were processed for dry preservation. The ethyl acetate fumes were used to kill the collected specimens. After that, specimens were carefully stretched with the help of a wooden spreading board, pinned, dried, tagged with a unique ID, arranged systematically, and stored in entomological collection boxes.

The reported specimens were identified morphologically up to generic and species levels with the help of modern taxonomic keys and available literature. The classification system and nomenclature were adopted as per the updated classification systems.

Data analysis

The diversity indices are quantitative measures of recorded species. The Shannon-Weiner diversity index (H'), Simpson's diversity index (D') for species dominance , and Species evenness (E) were calculated using the PAST Ver. 4.03 tool.

RESULTS

During the field survey, 2046 individuals were reported, belonging to 56 species under 47 genera, subfamilies, 40 tribes, 27 subfamilies, and 12 families of two suborders, Adephaga and Polyphega of the total collected, 691 specimens belonged to the family Scarabaeidae (15 species of 11 genera), followed by 499 to the Meloidae (7 species of 5 genera), 324 to the Tenebrionidae (6 species of 6 genera), 165 to the Coccinellidae (3 species of 3 genera), 114 to the Carabidae (6 species of 5 genera), 94 to the Chrysomelidae (7 species of genera), 64 to the Curculionidae (5 species of 4 genera), 35 to the Cerembycidae (1 species of 1 genus), 31 to the Buprestidae (3 species of 2 genera), 14 to the Bostrichidae (1 species of 1 genus), 9 to the Dermestidae (1 species of 1 genus), and 6 specimens to the Ripiphoridae (1 species of 1 genus). The abundance of coleopteran species, along with their taxonomic position and relative abundance among recorded species, is presented in Table 2, and the familywise taxonomic composition and abundance of coleopteran species are shown in Table 3. Among the

Table 2. Checklist of coleoptera diversity in the study area.

	Subfamily	Tribe	Species	Abundance	Relative abundance
			I. Adephaga		
Carabidae (Ground beetles)					
1	Anthiinae	Anthiini	*Anthia sexmaculata* (Fabricius 1787)	36	1.76
2	Harpalinae	Chlaeniini	*Chlaenius pretiosus* (Chaudoir 1856)	26	1.27
3		Stenolophini	*Stenolophus* sp.	4	0.20
4	Scaritinae	Scaritini	*Scarites indus* (Olivier 1795)	22	1.08
5			*Scarites* sp.	8	0.39
6	Trechinae	Bembidiini	*Bembidion* sp.	18	0.88
			II. Polyphaga		
Bostrichidae (Bostrichid beetles)					
7	Bostrichinae	Sinoxylini	*Sinoxylon* sp.	14	0.68
Dermestidae (Skin beetles)					
8	Anthreninae	Anthrenini	*Anthrenus* sp.	9	0.44
Buprestidae (Jewel beetles)					
9	Chalcophorinae	Psilopterini	*Psiloptera* sp.	11	0.54
10	Julodinae	Chrysochroini	*Sternocera chrysis* (Fabricius 1775)	9	0.44
11			*Sternocera aequisignata* (Saunders 1866)	11	0.54
Cerembycidae (Long-horned beetles)					
12	Lamiinae	Saperdini	*Obereopsis brevis* (Gahan 1894)	35	1.71
Chrysomelidae (Leaf beetles)					
13	Bruchinae	Acanthoscelidini	*Bruchidius* sp.	14	0.68
14		Pachymerini	*Caryedon serratus* (Olivier 1790)	33	1.61
15		Amblycerini	*Zabrotes subfasciatus* (Boheman 1833)	1	0.05
16	Cassidinae	Hispini	*Dicladispa* sp.	7	0.34
17	Chrysomelinae	Chrysomelini	*Zygogramma bicolorata* (Pallister 1953)	8	0.39
18	Criocerinae	Lemini	*Lema* sp.	9	0.44
19	Cryptocephalinae	Clytrini	*Clytra* sp.	22	1.08
Coccinellidae (Coccinellids/Ladybirds)					
20	Chilocorinae	Chilocorini	*Brumoides suturalis* (Fabricius 1789)	18	0.88
21	Coccinellinae	Coccinellini	*Cheilomenes sexmaculata* (Fabricius 1781)	82	4.01
22			*Coccinella septempunctata* (Linnaeus 1758)	65	3.18
Curculionidae (Weevils)					
23	Entiminae				
		Cyphicerini	*Myllocerus* sp.	28	1.37
24			*Myllocerus viridanus* (Fabricius 1775)	18	0.88
25		Laparocerini	*Cyrtozemia dispar* (Pascoe 1872)	5	0.24
26	Lixinae	Lixini	*Hypolixus truncatulus* (Fabricius & JC 1798)	5	0.24
27		-	*Atactogaster* sp.	8	0.39
Scarabaeidae (Scarab beetle)					
28	Cetoniinae	Cetoniini	*Chiloloba acuta* (Wiedemann 1823)	25	1.22
29			*Oxycetonia versicolor* (Fabricius 1775)	23	1.12

Table 2. Continued.

	Subfamily	Tribe	Species	Abundance	Relative abundance
30			*Protaetia alboguttata* (Vigors 1826)	42	2.05
31	Melolonthinae	Melolonthini	*Holotrichia* sp.	20	0.98
32		Schizonychini	*Scizonycha* sp.	2	0.10
33		Sericini	*Maladera insanabilis* (Brenske 1894)	26	1.27
34	Rutelinae	Adoretini	*Adoretus* sp.	45	2.20
35		Anomalini	*Anomala* sp.	61	2.98
36	Scarabaeinae	Coprini	*Catharsius molossus* (Linnaeus 1758)	9	0.44
37			*Catharsius granulatus* (Sharp 1875)	8	0.39
38			*Catharsius* sp.	27	1.32
39		Gymnopleurini	*Gymnopleurus cyaneus* (Fabricius 1798)	113	5.52
40			*Gymnopleurus miliaris* (Fabricius 1775)	177	8.65
41		Onthophagini	*Onthophagus* sp.	28	1.37
42			*Onthophagous gazella* (Fabricius 1787)	85	4.15
Meloidae (Blister beetles)					
43	Meloinae	Mylabrini	*Croscherichia goryi* (Marseul 1870)	116	5.67
44			*Hycleus* sp.	77	3.76
45			*Mylabris phalerata* (Pallas 1781)	119	5.82
46			*Mylabris* sp.	131	6.40
47			*Mylabris quadripunctata* (Linnaeus 1767)	17	0.83
48		Epicautini	*Epicauta* sp.	22	1.08
49		Lyttini	*Psalydolytta rouxi* (Castelnau 1840)	17	0.83
Ripiphoridae (Wedge-shaped beetle)					
50	Ripiphorinae	Macrosiagonini	*Macrosiagon bipunctata* (Fabricius 1801)	6	0.29
Tenebrionidae					
51	Blaptinae	Blaptini	*Blaps* sp.	61	2.98
52	Lagriinae	Lupropini	*Luperops* sp.	6	0.29
53	Pimeliinae	Adesmiini	*Adesmia cribripes* (Haag-Rutenberg 1875)	13	0.64
54		Pimeliini	*Pimelia* sp.	29	1.42
55	Tenebrioninae	Opatrini	*Gonocephalum* sp.	204	9.97
56		Triboliini	*Tribolium castaneum* (Herbst 1797)	11	0.54

Table 3. Species diversity and richness among different coleopteran families.

Sl. No.	Suborder	Family	Taxonomic composition					Abundance	
			Species richness	Genera	Tribe	Subfamily	Relative species richness	Individuals	Relative abundance
1	Adephaga	Carabidae	6	5	5	4	10.71	114	5.57
2	Polyphaga	Bostrichidae	1	1	1	1	1.79	14	0.68
3		Dermestidae	1	1	1	1	1.79	9	0.44
4		Buprestidae	3	2	2	2	5.36	31	1.52
5		Cerembycidae	1	1	1	1	1.79	35	1.71
6		Chrysomelidae	7	7	7	5	12.50	94	4.59
7		Coccinellidae	3	3	2	1	5.36	165	8.06
8		Curculionidae	5	4	3	2	8.93	64	3.13
9		Scarabaeidae	15	11	9	4	26.79	691	33.77
10		Meloidae	7	5	3	1	12.50	499	24.39
11		Ripiphoridae	1	1	1	1	1.79	6	0.29
12		Tenebrionidae	6	6	5	4	10.71	324	15.84

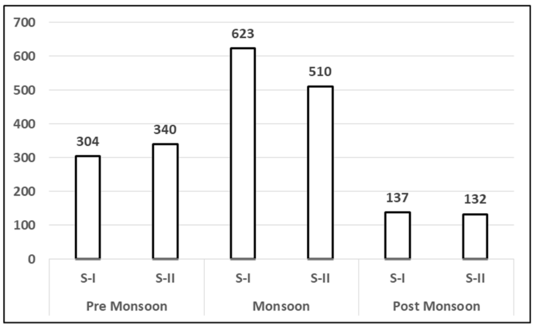

Fig. 2. Bar graph showing the fluctuations in the species abundance among seasons.

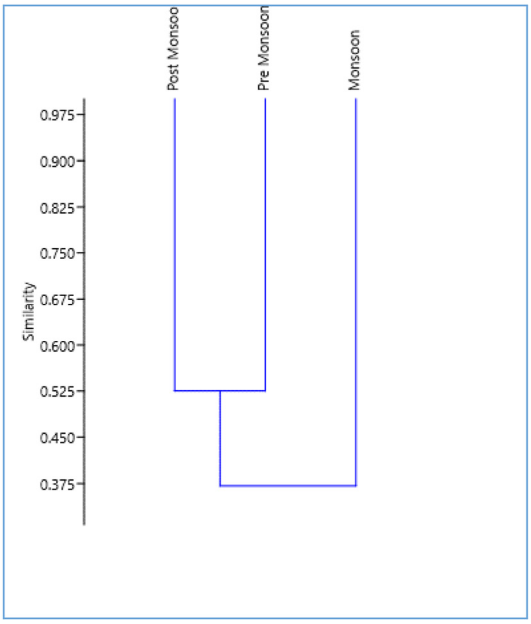

Fig. 3. Cluster analysis showing the species similarity in different seasons.

all recorded species, *Gonocephalum* sp. was found to be the most dominant with 204 individuals, followed by *G. miliaris* with 177 individuals and *Mylabris* sp. with 131 individuals, while *Z. subfasciatus, Scizonycha* sp., and *Stenolophus* sp. were the least abundant with 1, 2, and 4 individuals, respectively (Table 2). The maximum species diversity and abundance were reported during the monsoon season (July–October, 1133 individuals), followed by the pre-monsoon (November–February, 644 individuals), and the minimum during the post-monsoon (November–February, 269 individuals) (Fig. 2).

The similarity matrix (Bray Curtis scale) showed that coleoptera composition with pre-monsoon and post-monsoon is 0.755, monsoon and pre- and post-monsoon is 0.525, and seasons are similar to each other. The monsoon was formed of a single cluster, and species composition had much dissimilarity with other seasons of the study area (Fig. 3).

Across the field investigation, Simpson's Diversity Index (D'), Shannon Diversity Index (H'), and Dominance and Evenness (E) were calculated as 0.9574, 3.515, 0.04257, and 0.5987, respectively, which depicts that the coleopteran fauna is diverse in the surveyed areas. The Jhalana Forest has recorded a higher number of species richness and species abundance, 56 and 1064, respectively, than the Galta Forest, which was recorded as 55 and 982, respectively. Simpson's diversity index (D) and Shannon weiner's diversity index (H) values for Jhalana Forest were 0.9589 and 3.544 respectively, while Galta Forest was 0.956 and 3.489, respectively. Jhalana Forest had the highest evenness (E) at 0.6179, while Galta Forest had the lowest at 0.6063 (Table 4).

DISCUSSION

Both the selected sites consist of sparse vegetation with xeric adaptations and seasonal fluctuations

Table 4. Species diversity attributes of recorded species of coleoptera from Aravalli, Rajasthan.

Sl. No.	Sites name	Species richness	Abundance	Simpson's index (D')	Shannon weiner index (H')	Evenness (E)	Dominance
1	Jhalana Forest	56	1064	0.9589	3.544	0.6179	0.04109
2	Galta Forest	54	982	0.956	3.489	0.6063	0.04397

(Kumbhojkar *et al.* 2019). The Jhalana Forest has high species richness due to good vegetation cover, government habitat conservation strategies, and very few anthropogenic activities. The Galta Forest had poor landscape management and reported various types of sacred activities in conjunction with other anthropogenic activities, such as cattle grazing, firewood collection, human encroachment of fringe areas, and invasion of *Lantana* sp. and *Prosopis juliflora,* and thus the Jhalana Forest contributes to high species diversity and abundance of coleopteran fauna. Among the collection, the genera *Catharsius* and *Mylabris* dominate the recorded species, with 3 species each, and *Scarites, Sternocera, Myllocerus, Gymnopleurus, Onthophagus* are represented by 2 species each, while the rest of the genera are represented by a single species each. In the account of species abundance, *Gonocephalum* sp. was found dominant among all with 204 individuals, while *Z. subfasciatus, Scizonycha* sp., and *Stenolophus* sp. were the least abundant reported with 1, 2, and 4 individuals subsequently. Earlier studies by Basu *et al.* (2017) and Singh *et al.* (2018) found similar results for coleopteran diversity in the different types of tropical deciduous forest ecosystems in India. As reported by Price (2004), the population of coleopterans shows seasonal fluctuations in response to environmental parameters, with a maximum in the monsoon. Nilsson and Soderberg (1996) found similar results and provided explanations for a positive relationship between the distribution of coleopteran species and abundance. Jhalana Forest's species diversity is high because of the vegetation cover, ecological conservation, and habitat management strategies of the government. Also, this park serves as a nascent habitat for a vulnerable species of big cat, artificially colonized by water and vegetation. On the other hand, the Galta Forest, comparatively, is less diverse, maybe because of habitat type, sparse vegetation cover, poor management strategies, plant invasion, and anthropogenic activities. The abundance and diversity of coleopteran fauna are directly proportional to the variety of vegetation and less anthropogenic influences because their adults and larvae rely on the type of vegetation, forest cover, and structure for food and shelter. Banerjee (2014), and Barratt *et al.* (2015) described the negative impacts of various anthropogenic activities on coleopteran diversity in forest ecosystems.

CONCLUSION

The present study reveals the coleopteran diversity of forest habitats in the Aravalli Range of Jaipur, Rajasthan. Coleopteran species were seen in large number on grass patches in between the foothills of Jhalana Forest in the Aravalli hill range. These types of faunal biodiversity assessments are vital for long-term ecosystem monitoring of species occurrence, the designing of conservation models, and the development of management strategies for the landscape by forest officials. A long-term study covering biodiversity and population dynamics is recommended in this landscape for the study of changes in the dry deciduous forest of the Aravalli Range, Rajasthan. It would be helpful for the identification of insect fauna and to derive conservation policies and make sustainable use of biotic resources.

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